PATENT SPECIFICATION

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784,742

Date of Application and filing Complete Specification: Aug. 9, 1954.

No. 23084/54.

Complete Specification Published: Oct. 16, 1957.

Index at acceptance:—Classes 39(1), D(9C: 9D: 9F: 9G: 9H: 10D: 11: 12E: 16A2: 17A3: 46A); and 83(4), S4.

International Classification:—B23k. H01j.

COMPLETE SPECIFICATION

Improvements in Electron Tubes

We, EITEL-MCCULLOUGH, INC., a Corporation organised and existing under the laws of the State of California, United States of America, and having a place of business at San Bruno, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electron-tubes and more especially (though not exclusively) to tubes of the velocity modulated type, having cavity resonators.

The invention provides an electron-tube comprising an evacuated envelope, an annular metal section and an annular ceramic section adjacent thereto which sections constitute a part of the envelope, flexible vacuum-tight sealing means between the adjacent parts of the sections, and an annular metal element having the form of a short length of tube which element extends in a generally axial direction between the adjacent parts of the sections whereby to take axial thrust between them but does not provide a seal between said sections, the cross-section of said element being such as to permit deformation thereof on differential thermal expansion of the sections in a direction perpendicular to the axis thereof.

The features of the present invention are intended to be particularly useful in externally tunable klystrons of the type disclosed in U.S.A. Patent Specification No. 2,619,611, issued November 25th, 1952.

This specification shows an electron-tube having cavity resonator portions, which form part of the evacuated envelope, these resonator portions comprising metal end walls and a ceramic cylinder extending between them; these elements are also present in constructions according to the invention, the present invention providing *inter alia* an improved arrangement for sealing the ceramic cylinder to the end walls.

A preferred embodiment of the invention will now be described with reference to the accompanying drawing in which:—

Figure 1 is a side elevational view of part of a three-resonator klystron;

Figure 2 is an axial sectional view of the same, and

Figure 3 is an enlarged fragmentary view showing the construction of a cavity resonator portion.

The tube illustrated is particularly designed as an amplifier in the UHF region having a power rating of several kilowatts CW. Figures 1 and 2 show the evacuated tube per se apart from the external structure. In the final use of such a tube suitable external resonator portions are applied as described in the above mentioned patent specification, one of such external resonator portions being indicated by the dotted lines 1 in Figure 1.

The tube comprises an elongated generally cylindrical envelope having an electron gun 2 at one end and a collector electrode 3 at the other end. The electron beam from the gun to the collector passes through a tube made up of aligned metal sections 4, 6, 7, and 8 extending axially of the envelope and having gaps 9, 11 and 12 therebetween. Such gaps are bridged by cavity resonator portions forming part of the tube envelope and generally designated 13, 14 and 16.

Electron gun 2 includes a disk-shaped cathode 17 and a surrounding focusing electrode 18, the cathode being heated by a filament 19; all these elements are supported by a glass stem 21 forming part of an end of the evacuated envelope. Cathode 17 is preferably of a material such as tantalum heated by electron bombardment from the filament, all in accordance with conventional practice.

The electron gun is housed in a cup-shaped metal section 22 of the envelope, which section is of iron and functions both as an anode for the gun and as a pole piece

for a suitable external focusing magnet. Stem 21 is supported on the pole piece 22. An aperture 23 in the iron pole piece 22 is aligned with the cathode and is coaxial with the tube formed by the sections 4, 6, 7, 8.

Collector 3 at the opposite end of the envelope to the electron gun comprises a hollow metal electrode 24 supported from a disk-shaped metal section 26 of the envelope. A glass envelope section 27 sealed between flanges 28 provides a supporting connection between the collector electrode and the envelope section 26. An aperture 29 in the metal section 26 is aligned with the collector electrode and is coaxial with the drift tube. The metal section 26 is a disk of iron and also functions as a pole piece for the external focusing magnet.

With the above described structure an electron beam from gun 2 is accelerated by a positive potential on the pole piece 22 acting as anode and passes through the tube sections 4, 6, 7, 8, past the interaction spaces provided by gaps 9, 11 and 12, and finally terminates on the collector electrode 3, the beam being directed down the tube sections by an external magnet associated with iron pole pieces 22 and 26. The three cavity resonators comprising portions 13, 14 and 16, coacting with the interaction spaces at gaps 9, 11 and 12, serve as the frequency determining elements of the device. In the tube illustrated, which functions as an amplifier, the input signal for modulating the electron stream is fed into the first resonator comprising the portion 13, and the radio-frequency output is taken from the third resonator comprising the portion 16, as is usual for three-cavity type klystrons.

As previously mentioned herein, the particular kind of tube shown is adapted for external tuning by the use of suitable external resonator portions, one of which is indicated by the dotted lines 1 in Figure 1: each complete resonator comprises a portion forming part of the envelope, such as 16, and a cooperating external portion, such as 1. The use of such external resonator portions for tuning over a wide band of frequencies is possible, of course, because of the sealed-off nature of the resonator portions 13, 14 and 16 which comprise part of the evacuated envelope.

Continuing with the description of Figures 1 and 2, the end tube section 4 is brazed to the pole piece 22, and the other end section 8 is brazed to the section 26. The intermediate tube sections 6 and 7, as has been said, are axially aligned with the end sections 4 and 8, and these several sections form parts of the side walls of the evacuated envelope. The resonator portions 13, 14 and 16, which are disposed transversely of the envelope axis, are mounted on the tube sections and form additional side wall portions of the evacuated envelope. In other words, the resonator portions provide vacuum-tight walls bridging the gaps between the tube sections.

Input resonator portion 13 comprises parallel disk-shaped metal end walls 31 and 32 brazed to the tube sections 4 and 6, these end walls also being preferably of copper. A cylinder 33 of insulating material is sealed between such end walls. In the interest of mechanical strength and electrical properties the cylinder 33 is of a ceramic material, such as the alumina or zircon type ceramic bodies. Cylinder 33 is supported by axially extending flanges 34, preferably of copper, brazed to the opposing surfaces of side walls 31 and 32. The ceramic is metallically bonded to the copper flanges by known ceramic-to-metal bonding techniques, such as by first metalising the ends of the ceramic by the molybdenum powder sintering process and then brazing the metalised ends to the metal flanges with silver solder or the like.

Since the ceramic materials have a lower coefficient of thermal expansion than metals of good electrical conductivity, such as copper, the flanges 34 are given a U-shape to provide folded back inner lips 36 connected to the ceramic. This provides a good mechanical arrangement and also sufficient flexibility in the structure to accommodate differences in expansion. Another advantage of this construction is that the rounded faces of the flanges, i.e. the bights of the U's, face each other, and thereby provide desirable corona rings to reduce sparking between the resonator walls. In combination with the U-shaped flanges, metal spacing rings 38 are provided to project from the end walls to abut the ends of the ceramic. These rings take axial thrust between the end walls and the ceramic and prevent the flexible flanges from collapsing when the tube is evacuated. When differential thermal expansion occurs perpendicular to the axis of the tube the spacing rings deform slightly to accommodate this expansion. Thermal expansion and contraction axially of the tube presents no problem since in normal use of the tube it is always held so as to allow the slight movements involved.

The intermediate resonator portion 14 is of similar construction, having end walls 39 and 41 with a ceramic cylinder 42; output resonator portion 16 is of like construction, having end walls 43 and 44 with a ceramic cylinder 46. In each of the three resonators the disc-like end walls have outer edges providing terminals with which suitable contact fingers on the cooperating external resonator portions may be engaged.

Provision is made in the tube illustrated for cooling the tube comprising sections 4, 6, 7, 8, and associated parts, such cooling being of special importance in a power tube of this

kind where one is dealing with kilowatts of power. As best shown in Figure 2, metal sleeves 47 and 48 are provided about the tube sections 6 and 7, sleeve 47 being brazed between resonator portion walls 32 and 39 and sleeve 48 being brazed between walls 41 and 43. These sleeves are spaced from the tube sections to provide water jackets, suitable inlet and outlet connections 49 being provided so that water can be circulated through the jackets. Such structure is very effective because the ends of the resonator portions as well as the tube sections are adequately cooled. The sleeves 47 and 48 also serve as reinforcing members to provide additional strength axially of the tube, which is of considerable importance in a tube of this kind where appreciable length and massive parts are involved.

Cooling means are also provided for the pole pieces 22 and 26 and the adjacent tube sections and resonator walls. As seen at the cathode end of the tube, a sleeve 51 is disposed about tube section 4 and is brazed between the pole piece 22 and the resonator portion wall 31, thus providing a water jacket for those parts. Water connections are made by the ducts 52 at the outer end of the pole piece communicating with the water jacket via passages 53. A like arrangement is incorporated at the opposite end of the envelope by means of the jacket sleeve 54, ducts 56 and passages 57 in pole piece 26. Such structures provide adequate cooling for the pole pieces and associated tube sections, as well as the adjacent end walls of the resonators. Sleeves 51 and 54 also serve as reinforcing struts at these points.

Referring again to Figure 2, it will be seen that hollow collector 24 is a cup-shaped electrode disposed axially of the tube. This is a drawn piece, preferably of copper. In order to avoid spot heating by the beam being focused on the end of the collector electrode, it is provided with an insert 58, also of copper, having a tapered bore 59 extending axially of the tube. This structure spreads the impinging electrons along the length of the electrode and also provides uniform conduction of heat to the outer surface of collector 24. The cooler for the collector electrode comprises a water jacket 61, with inlet and outlet ducts 62 and 63, and having an inner tubular deflector 64 for directing the inlet water along the sides of the electrode in parallelism with the bore 59. With this construction even though high energy electron beams are employed, many kilowatts of power may be dissipated without difficulty.

The exhaust tube for the envelope is also incorporated in the collector electrode structure. As shown, the bore 59 continues through the insert 58 and communicates with a metal tube 60 brazed to the end of cup 24. After evacuation of the envelope this tube is pinched off at tip 65.

In the specification of my copending Application for Letters Patent No. 27,053/56 (Serial No. 784,743) there is described and claimed a velocity modulated type electron-tube, comprising an elongated evacuated envelope, an electron gun at one end of the envelope and a collector electrode at the other end, a straight tube extending axially of the envelope and forming side walls of the evacuated envelope, said tube comprising spaced sections with gaps therebetween, a plurality of cavity resonator portions disposed transversely of the envelope axis at the gaps, said resonator portions comprising metal end walls mounted on adjacent tube sections and extending outwardly from said sections, means providing vacuum - tight walls across the gaps, and a water jacket surrounding the tube section between a pair of adjacent resonator portions, and comprising a sleeve connected between the adjacent end walls of the latter resonator portions.

What we claim is:—

1. An electron tube comprising an evacuated envelope, an annular metal section and an annular ceramic section adjacent thereto which sections constitute a part of the envelope, flexible vacuum tight sealing means between the adjacent parts of the sections, and an annular metal element having the form of a short length of tube which element extends in a generally axial direection between the adjacent parts of the sections whereby to take axial thrust between them but does not provide a seal between said sections, the cross-section of said element being such as to permit deformation thereof on differential thermal expansion of the sections in a direction perpendicular to the axis thereof.

2. An electron-tube as claimed in Claim 1, wherein the metal element is separate from the metal section and the metal section has a locating shoulder against which the element is positioned.

3. An electron-tube as claimed in Claim 1 or in Claim 2, wherein the flexible sealing means comprises an axially extending metal flange on the metal section which is return-bent to define, as seen in longitudinal section, a pair of limbs, the metal section being joined to one limb of the flange and the ceramic section being metallically bonded to the other limb of the flange.

4. A velocity modulated electron-tube according to any of Claims 1 to 3, comprising at least two metal sections forming end walls of a cavity resonator portion and extending transversely to the envelope axis, the ceramic section being cylindrical and located between the end walls to be coaxial with the envelope.

5. A velocity-modulated electron-tube as claimed in Claim 4 as dependent on Claim

3, wherein the U-shaped flanges have their bights facing each other.

6. A velocity modulated electron-tube as claimed in Claim 4 or in Claim 5, comprising a straight tube extending from a position adjacent an electron gun, providing walls of the envelope, functioning over at least part of its length as a drift tube and formed in at least three aligned sections with gaps therebetween, and a cavity resonator portion as aforesaid bridging each gap.

7. A velocity modulated electron-tube as claimed in Claim 6, comprising a collector electrode adjacent the end of the straight tube remote from the gun and aligned therewith and with the tube.

8. An electron-tube as claimed in Claim 6 or in Claim 7, wherein a water jacket is provided to surround the tube section between the or each pair of adjacent resonator portions, said jacket comprising a sleeve connected between the adjacent end walls of the latter resonator portions.

9. An electron-tube according to Claim 8, comprising pole pieces adjacent opposite ends of and forming portions of the envelope, wherein a water jacket is provided to surround the tube section between a resonator portion and a pole piece and comprises a sleeve connected between the pole piece and the end wall of the latter resonator portion.

10. An electron-tube as claimed in Claim 7, or either of Claims 8 and 9 as dependent on Claim 7, wherein said collector electrode is a cup-shaped metal member, and a metal insert is provided in the electrode having a tapered bore axially aligned with the tube, the larger end of the insert facing the electron gun.

11. An electron-tube as claimed in Claim 10, wherein a metal exhaust tube is provided on the collector electrode, which exhaust tube communicates with the bore in the insert.

12. An electron-tube as claimed in Claim 10 or in Claim 11, wherein a water jacket is provided which surrounds the collector electrode and is associated with a deflector for directing water along the sides of the electrode in parallelism with the bore in the insert.

13. The velocity modulated type electron-tube herein described with reference to the accompanying drawing.

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Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1957
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

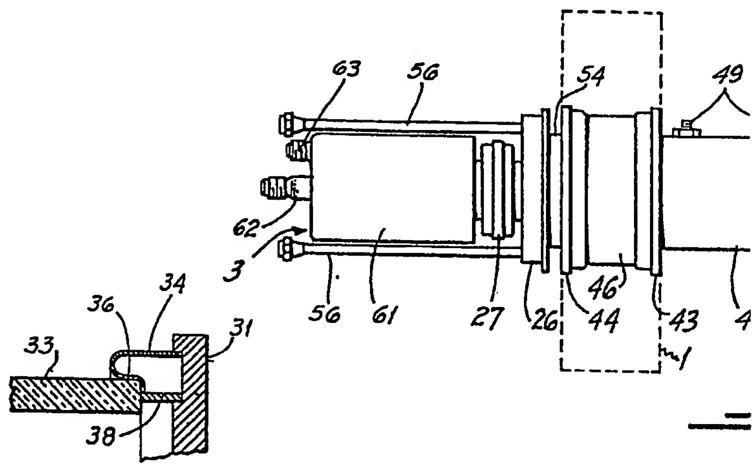

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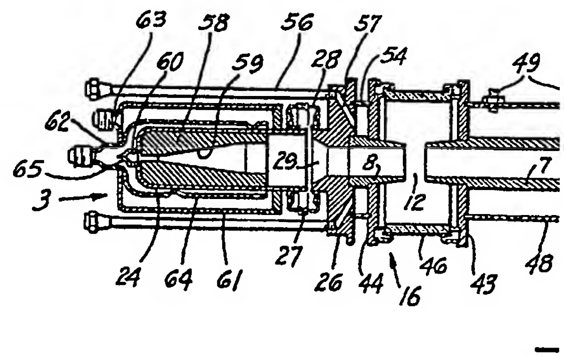
Fig.3



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784,742 COMPLETE SPECIFICATION
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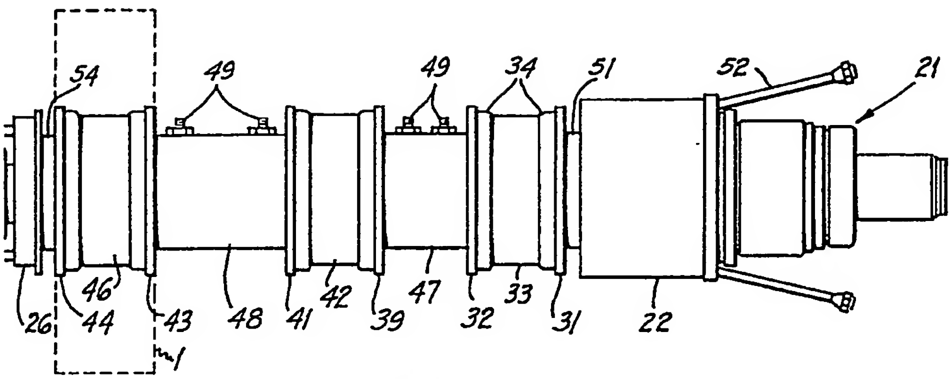

Fig.1

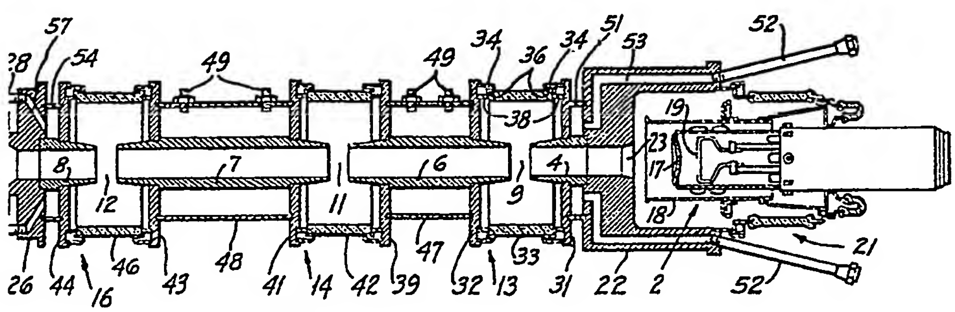

Fig.2

784,742 COMPLETE SPECIFICATION
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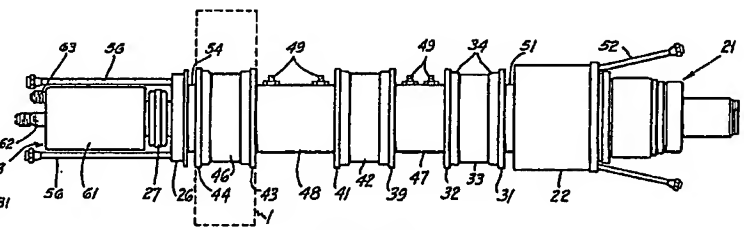

Fig.1

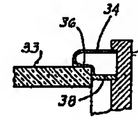

Fig.3

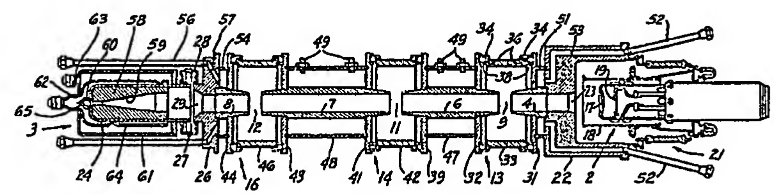

Fig.2